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THE PERFORMANCE OF SUB-CALIBER PROJECTILES COMPARED WITH THAT OF CONVENTIONAL TYPES

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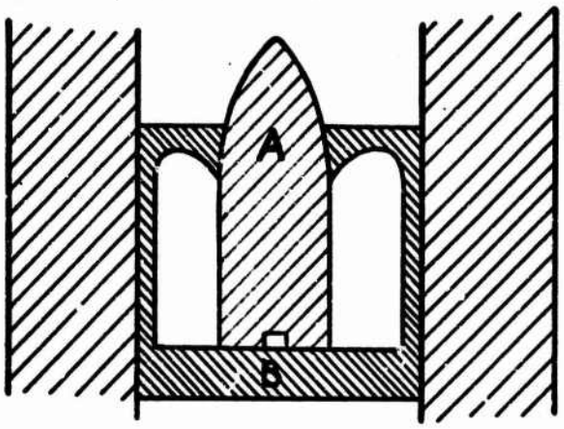
Abstract

Sub-caliber projectiles are compared with those of conventional type for A.A. and anti-tank purposes. While the sub-caliber projectiles have somewhat shorter times of flight than the conventional ones, the difference is hardly great enough to offset their much smaller weight. In the 75 mm gun, the sub-caliber projectiles should have greater penetrations up to about 1000 yds but here again the advantage is so slight that it makes the adoption of the sub-caliber projectile of doubtful advisability. It appears that sub-caliber projectiles could be more advantageously used in large than in small guns.

A sub-caliber projectile is a projectile of a diameter considerably smaller than the diameter of the bore in which it is fired. It is supported in the bore by a carrier as shown in the following figure.



In the figure, A is the sub-caliber projectile and B is the carrier. After the carrier reaches the muzzle it breaks open by centrifugal force and the projectile proper, A, proceeds along its trajectory.

During the World War I, the French experimented with sub-caliber projectiles and about two years ago the Brandt Company showed projectiles of this type to the Ordnance Department. More recently, the possibilities of this type of projectile have been brought to the attention of the writer by Mr. Poitras and Dr. Weaver of the N.D.R.C.

The French sub-caliber projectiles of World War I were unsuccessful apparently because they were not given enough spin to make them stable. It seems that it was not realized that for homologous projectiles to have equal stability factors, the spin must vary inversely with the caliber. If a 75 mm gun should have a twist of 1/25 to fire the normal projectile, it should have a twist of approximately 1/12.5 to fire an homologous 37 mm sub-caliber projectile.

Sub-caliber 37 mm projectiles are considered for two guns, the 75 mm gun Mod. 1897 and the 3" gun M3. The sub-caliber projectile is taken to have a weight of 1.5 lb. and the carrier the same weight so that the weight of the total projectile, i.e., of sub-caliber projectile and carrier, would be 3 lb.

The muzzle velocities of the sub-caliber projectiles have been computed by J. R. Lane on the assumption that the weight of charge and maximum pressure are the same as with the standard projectile. The results are given in Table I.

Table I

Gun	Wt. of Stand. Proj. lb	Vel. of Stand. Proj. f/s	Charge lb	Max. Press. lb/in^2	Calculated Vel. of 1.5 lb Sub-cal. Proj. f/s
75 mm	14.7	1950	1.91	33,600	4,000
3"	12.7	2800	4.34	33,000	5,000

Using the muzzle velocities and weights of Table I, trajectories were computed by M. E. Harrington with the results shown in Figs. 1 - 4 incl. From these the following results are taken.

Table II

Slant Range	Time of Flight			
yd	75 mm Proj.	37 mm Proj.	3" Proj.	37 mm Proj.
5000	11.4	6.7	7.3	4.8
10000	33.6	28.6	22.9	18.5

If in accordance with the results given in B.R.L. Report No. 127, the probability of hitting an airplane by A.A. fire is taken as inversely proportional to the square of the time of flight, it is apparent that the sub-caliber high velocity projectiles would have an advantage in proportion of hits over those of conventional type, but this advantage is hardly great enough to compensate for the great reduction in weight of projectile. An additional disadvantage of the sub-caliber projectile is that pieces of the carrier might kill or wound friendly troops in the vicinity of the gun.

Although these sub-caliber projectiles seem to possess insufficient merits to warrant their adoption for A.A. use there is a possibility that they might be superior to the conventional projectile for anti-tank purposes. To determine whether this is the case, remaining velocities and penetrations were computed for the two sub-caliber projectiles mentioned in Table I. The results are given in Table III.

Table III

Cal.	Wt. of Proj. lb	M.V. f/s	Range yd	Striking Velocity f/s	Penetrations* at Normal Impact in
75 mm	14.7	1950	500	1836	3.52
			1000	1725	3.23
37 mm	1.5	4000	500	3642	3.89
			1000	3293	3.40
3"	12.7	2800	500	2643	5.13
			1000	2491	4.73
37 mm	1.5	5000	500	4618	5.33
			1000	4246	4.76

With the good ballistic shape of the Type 2 projectile it appears that in the 75 mm gun the sub-caliber would have an advantage in respect to penetration over the conventional projectile if it could be made to have a suitable stability factor but in the 3" gun the superiority is negligible. Actually it might be difficult to make an A.P. projectile with as good a shape as that of the Type 2. The smaller weight of the sub-caliber projectile would tend to offset its greater penetrating power when fired from the 75 mm gun.

It appears that a sub-caliber projectile fired in a larger gun, e.g., 6" would have greater advantages over the conventional type than one fired from a 75 mm or 3" gun because of the smaller retardation of the heavier projectiles. In fact if the flying fragments of the carrier could be tolerated, as they might well be on shipboard, a sub-caliber projectile for a 6" A.A. gun armed with an impact fuze (see B.R.L. Report No. 264) might prove to be an effective method of attacking large bombers. Although it is likely that a 6" A.P. projectile would be capable of penetrating any tank armor, it might not be capable of penetrating turrets of fixed defenses. For attacking such targets a sub-caliber projectile 3" in diameter fired from a 6" gun might be worth trying. Of course, in designing a sub-caliber projectile, care should be taken to see that its stability factor exceeds unity.

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* With de Marre K = 1.15.

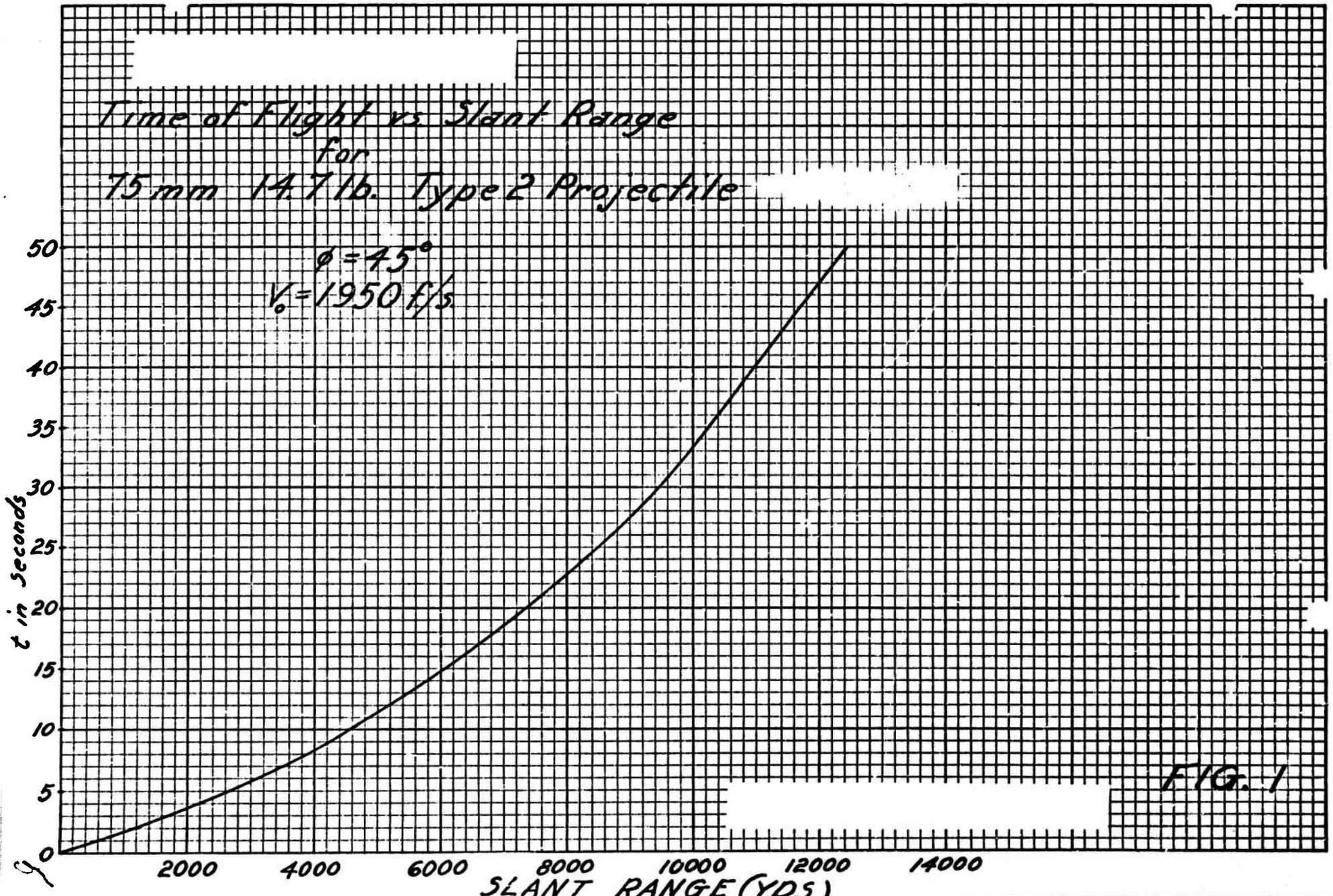
Time of Flight vs Slant Range
for
75 mm 14.7 lb. Type 2 Projectile
φ = 45°
V₀ = 1950 f/s
t in seconds
0
5
10
15
20
25
30
35
40
45
50
2000
4000
6000
8000
10000
12000
14000
SLANT RANGE (YDS.)

FIG. 1

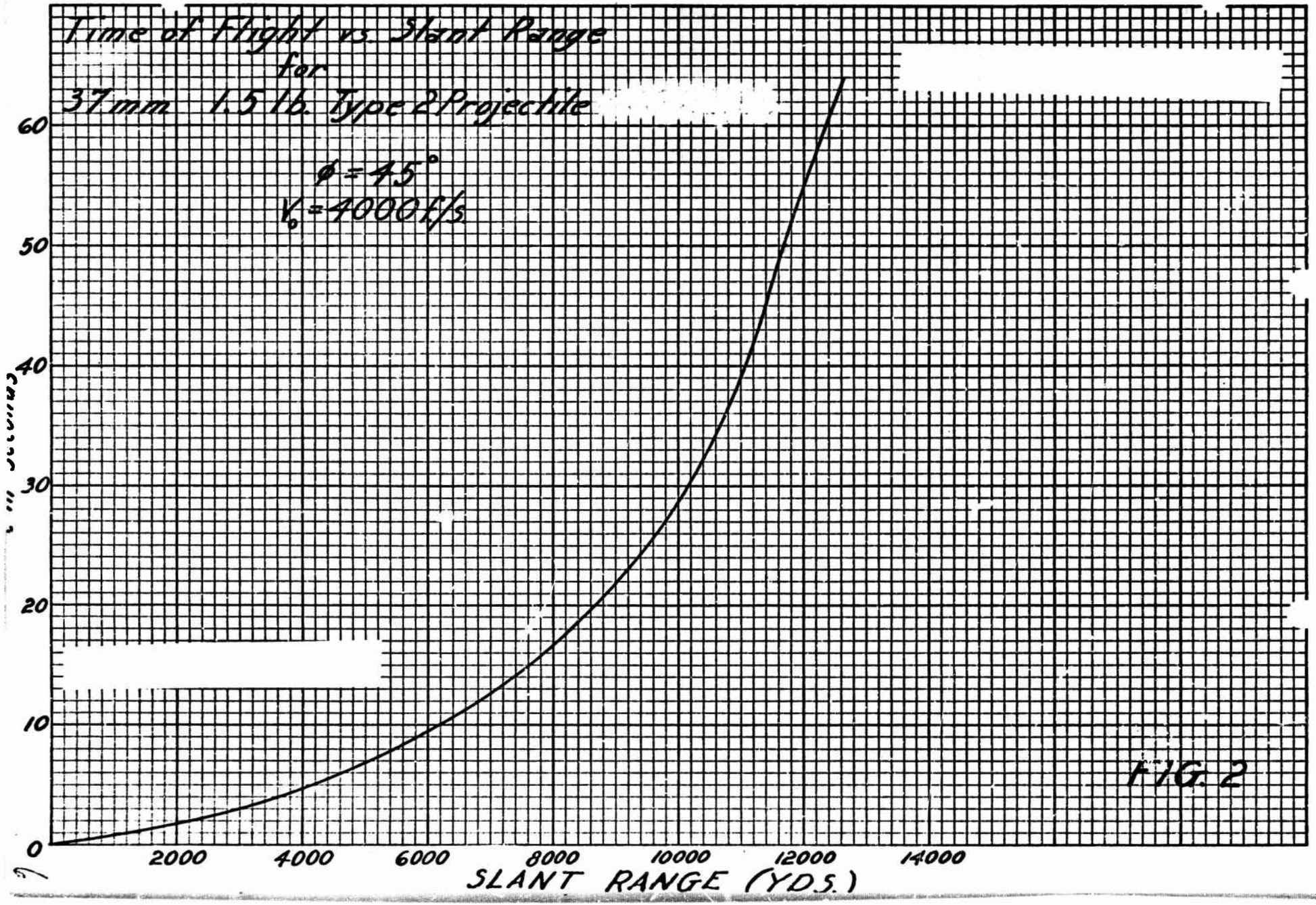
Time of Flight vs. Shot Range
for
37mm 1.5 lb. Type 2 Projectile
$\phi = 45°$
$V_0 = 4000$ f/s
60
50
40
30
20
10
0
2000
4000
6000
8000
10000
12000
14000
SLANT RANGE (YDS.)

FIG. 2

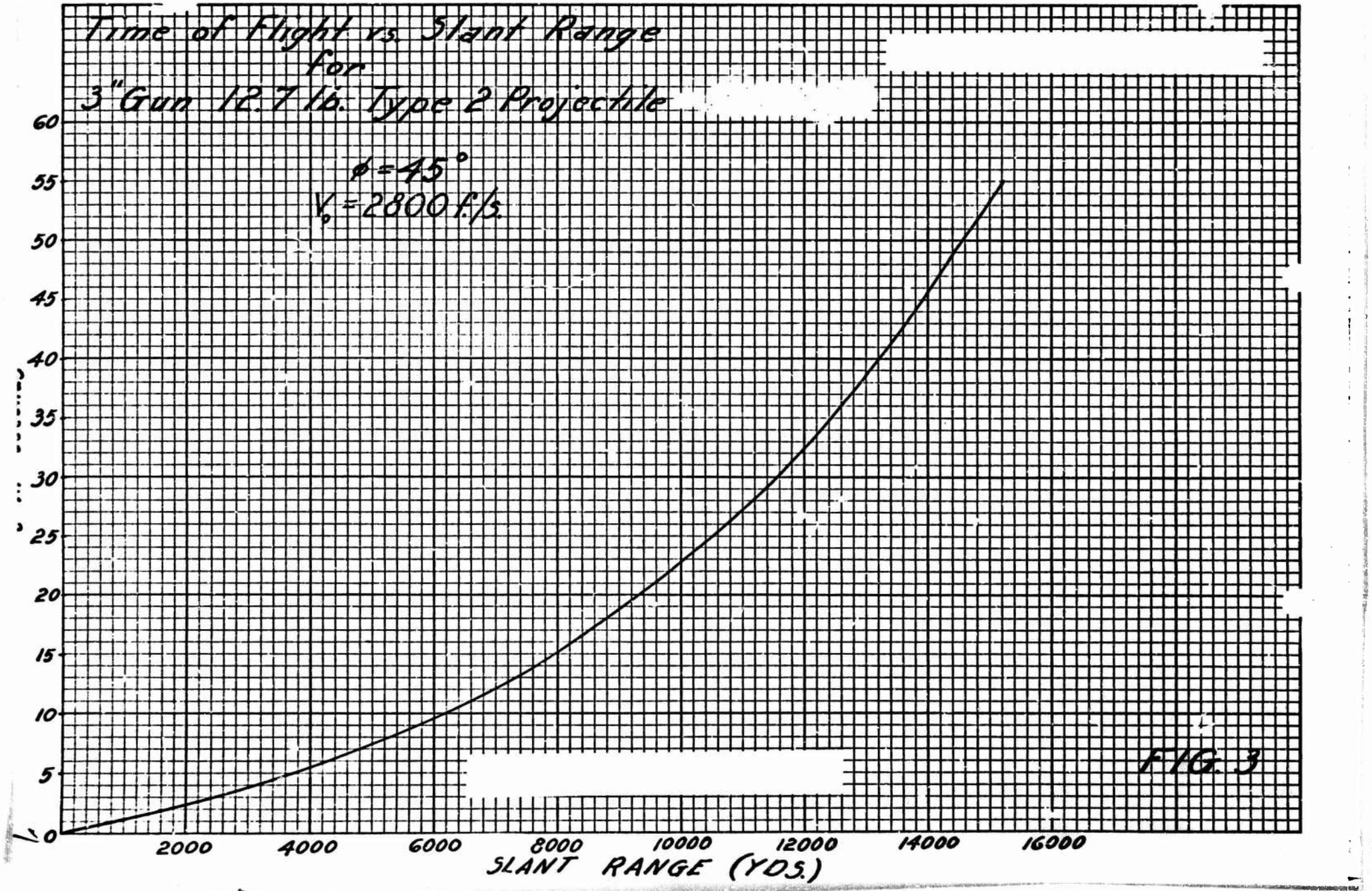
Time of Flight vs. Slant Range
for
3" Gun 12.7 lb. Type 2 Projectile
φ = 45°
V₀ = 2800 f/s.
60
55
50
45
40
35
30
25
20
15
10
5
0
2000
4000
6000
8000
10000
12000
14000
16000
SLANT RANGE (YDS.)

FIG. 3

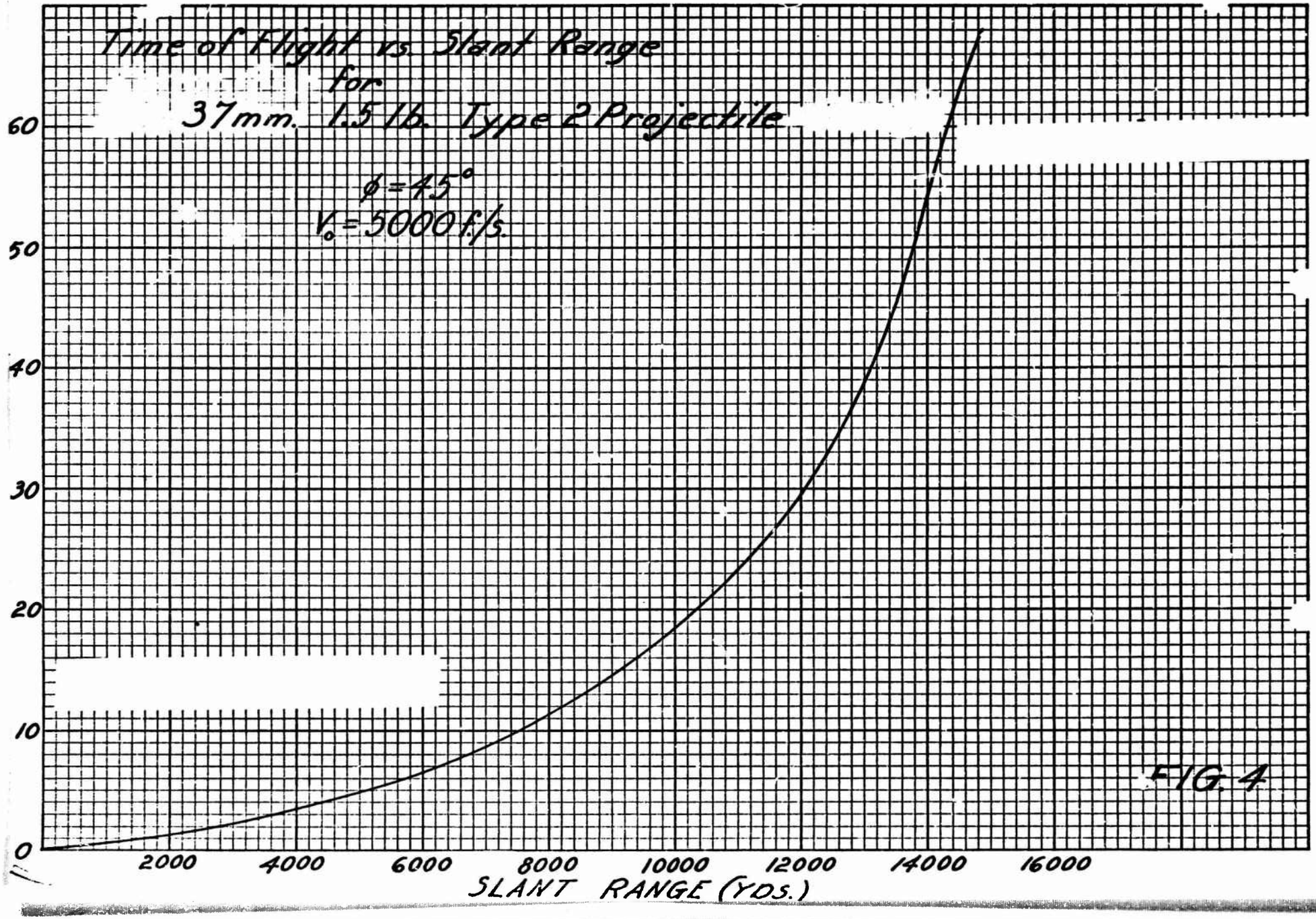
Time of Flight vs. Slant Range
for
37mm. 1.5 lb. Type 2 Projectile
$\phi = 45°$
$V_o = 5000$ f/s.
60
50
40
30
20
10
0
2000
4000
6000
8000
10000
12000
14000
16000
SLANT RANGE (YDS.)

FIG. 4